

A Submission to
The Annals of the History of Computing

A Draft
With a Working Title of
"A STORY OF ASCII"

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About Content and References

This is not an exhaustive history -- the group of fields where ASCII has application and effect is too large. It is not too scholarly -- Eric N. Fischer has the franchise on that, and can answer such questions as "why was the question mark put here instead of the vertical bar?"

One will note that certain aspects of ASCII are mentioned little in the text, and have no references given. Some are dead-ends now, some were failures, some are fairly immaterial. They are, with explanations for their omission:

Pre- and Post-ASCII Codes -- Few details are given about coded character sets previous to ASCII, and if so, mentioned only in passing (e.g., Fieldata). The (very large) story of UNICODE, promoted as the successor to ASCII, is not treated here. Many chapters already exist elsewhere.

Development of natural language codes can be left to the various countries or groups that use them, although the tie-in via ISO registry [151] will be explained.

4-bit Subsets of ASCII -- Now that we're living with a 16-bit UNICODE, we don't worry much about economy any more.

The use of 4 bits for packed decimal notation and arithmetic is not known to exist anywhere in the ASCII world. Only systems in the IBM 360 style, with EBCDIC, do so. It is a terrible resource waster, and apologies are tendered for any part in this played by me. With today's cheap storage we can't afford people time to program transformations.

The IBM PC, and its many copies, do arithmetic directly upon the 8-bit representations of ASCII digits -- a very clever and patented scheme. We may expect all mention of 4-bit codes to disappear from the standards documents.

Character Recognition -- There used to be big fusses about special fonts for recognition by magnetic ink or optical scans. No more. So the few ASCII-related standards dealing with this are passè. An \$80 scanner today will do all such work with software so cheap that it is not priced separately. And it is not font-specific to the user.

Graphics for the control characters of ASCII -- There used to be such a standard, even at international level. No manufacturers would display them on the screens, so the standard was withdrawn officially in 1995.

If you must have these, references about these can be found in [140], grouped by logical and physical aspects. In contrast, the references in this paper are ordered by date, grouped by year, and followed by clusters of reference numbers for those aspects.

So this is a story about how ASCII came about, from a marketplace and people point of view. How and why did it happen? Who were the players? Why did it take hold, grow, and affect the entire world?

It's a story filled with cliffhangers like an early movie serial, when you weren't sure that the heroine would survive the latest peril. It's a story about stupidities on the most grandiose scale. But it's a story about many, many dedicated and selfless people who understood the need and its importance, And it's a story with a happy ending for the whole world.

Entrance of One Player

My first adult jobs were at the Douglas Aircraft Company in Santa Monica, California, before and during World War II. There I received a modest introduction to calculating equipment, and managed to become fairly adept with the Friden desktop calculator, as powered by an electric motor. Admittedly IBM punch card equipment would have been in use there, in the accounting department, but I never saw it.

After leaving Douglas (voluntarily, I believe) at war end, I turned to architectural work, movie set design at RKO, and building custom furniture for movie stars.

On April 15 of 1949 I began work at the RAND Corporation, also in Santa Monica, having known some of the people there who had also worked at Douglas. That momentous day I began to suspect that I might have been genetically constructed to work with computers.

I was introduced to the IBM 601 calculating device. Six of them, in fact, and two could not only add and subtract (like the other four) but could also multiply and divide. Unfortunately at just a five operations per second rate.

And I met printers, reproducers, collators, keypunches, and sorters in similar plurality. They represented the computing world as it was then, and from the reasons that they existed we may see why ASCII was, if not inevitable, at least desirable.

I did not see punched paper tape, for I was in Cardland, USA. I knew that it existed and also carried alphanumeric information, but, not yet having been out of this country, I was but poorly aware of this alternate means of use with computers.

Those Punch Cards

Punch cards stored various characters, each in a single column. But such characters could have been, and were, assigned to various punch combinations. The upper case alphabet was operable then, but the available character repertoire was not *the* limiting factor. It was the length of the card, the number of columns (i.e., characters) it could hold, that caused all these other devices to exist!

Think employees and payroll. There were many variables associated with a person -- name, employee number, address, security clearance, home phone, weekly hours worked, pay rate, income tax data and deductions, vacations, etc. Won't all fit on a single card, will they? Well, then we'll have to split the data up to put it on several cards, each carrying (in common) an identifier for the total record, plus a number identifying the subset of data fields recorded on that particular card.

Now suppose that we would like to calculate a new value, based upon information from two of these associated sets of cards, and there's no room left on either. We order (via the sorter) one set on our common key, then the second set on the same key. Then we intersperse the two sets, like shuffling the deck, into one set (via the collator).

Now we wire a plugboard for the reproducer, put our interspersed set into one feeder, a stack of blank cards into the other feeder, and let our plugboard control the punching of 1) the common key, 2) the wanted field from one card type, and 3) the wanted field from the other card type into the set of blank cards. We end up with a new deck of cards having only the fields we need, plus a lot of new blank columns where we can punch new data derived from these. We effectively make the punch card longer -- possibly very much longer.

Therefore Collating Sequence

The above is one of many reasons for having a file in a certain order. Another might be for printing the data in a certain sequence for humans -- like alphabetically on surname, or numerically on check number for a register. Whatever the reason, whether the data file is stored on cards or on magnetic or paper tape, such orderings are intrinsic to any computing installation that plans to have people as customers.

And they were de facto before any data was ever exchanged mechanically between business and government, between associated businesses, or even between subentities of large businesses. If you rented the traveling machines that converted Remington Rand's round hole punch cards (with 90 columns) to IBM's rectangular hole punch cards (with 80 columns), you might get some data interchange. But it was not common, and the data would have to be resequenced or reordered.

However, collating sequence is an unavoidable aspect of character sets and computer usage, a fact inconveniently ignored by the COBOL people for several years.

IMPETUS FOR LARGER CHARACTER SETS

I joined IBM in New York City in December of 1955. There my eyes were opened to the world of incompatibilities between different computers, and to their limitations. But the world wasn't going to change just because I found it foolish. In that case where did the pressures for a larger character repertoire come from?

As the generality of the computer as a tool became more obvious, people began asking "what about using it for my work". And usually their work meant using more characters than those available, for they published, used alphabets other than Roman (and Greek), and wrote mathematical formulas. I got the bug, and sent a blue sky memo to John McPherson in early 1957, proposing a computer to read audio speech, validate for legal aspects, spell correctly, and output typed material. A Florida newspaper began using a computer for typesetting in 1959.

Facilitation of Larger Character Sets -- Software

Beginning before 1957, FORTRAN demanded characters not in the existing commercial set, and got a few by hijacking the ones they didn't need and renaming them to represent arithmetic operators. etc.

That caused many difficulties and much confusion. How could one tell, by looking at a card, whether it was FORTRAN or payroll? I lived with that mess, too, for my early efforts while associated with the FORTRAN group were focused on "commercial", not "scientific" machines. I certainly had to face the problem in building FORTRANSIT, the second FORTRAN processor to exist.

In 1958 the ALGOL language specifications appeared, with a very large theoretical set of 116 symbols, escaping reality by calling it a "reference set". Herb Bright thought ahead. He proposed a similar set [4], but with only 64 characters, to the SHARE organization in 1958 Sep as a "point of departure for hardware implementation of the IAL".

At M.I.T. the experimental TX-2 computer was being used, in part, for word processing, especially technical diagrams which needed a lot of Greek symbols and line drawing (output on a scope). They made many modifications to a Flexowriter and IBM Model B (basket element) typewriter, and called it the Lincoln Writer [1,7].

Facilitation of Larger Character Sets -- Hardware

Printers

McPherson's 1403 band printer gave another push -- its continuously rotating band embossed with characters to strike from behind whenever a desired character happened to coincide with that character position in passing over the paper.

This was significant because previous mechanisms, rising bars of the Carroll Carriage and disks of drum printers, where each column was so equipped, could not accommodate much larger sets. Size and inertia would cause bleed while the element was being struck. The beauty of the 1403 printer was that one element serviced all columns, not just one.

240 positions on the band could handle 5 sets of 48 (the original punch card character set), 4 sets of 60 for that set as augmented for FORTRAN's new characters, or 2 sets of 120 (which would handle a full 7-bit code with a few control characters -- which ASCII turned out to be).

Central Processors (CPU)

The 8-bit code of IBMs STRETCH made it simple to get more usable characters. It had 120 graphic characters and NO control characters at all! Not even a CR. (Definitely designed for supercomputing, and not for an Internet node, which is why my group designed an ASCII-like code [21] that could do so). The group at Los Alamos (the original customer) designed its own input character set originally, for which IBM built a special entry typewriter [13].

I had a great opportunity to start on the standards road when invited by Dr. Werner Buchholz to do the main design of the 120-character set [9,24] for the Stretch computer (the IBM 7030). I had help, but the mistakes are all mine (such as the interspersal of the upper and lower case alphabets).

The 6-bit code called Fieldata (which could be modified into 7 bits) had as its major driving force one Bill Luebbert [5,12,14]. It was started at about the same time as the STRETCH design, so we don't know if the latter influenced him at all. But providing only an upper case alphabet, he didn't make the same mistake I made for STRETCH by interspersing both cases of the alphabet!

Facilitation of Larger Character Sets -- Communications

Here Teletype was really the MAJOR force. The company's old lines were becoming superannuated. They ran with 5-track code and a 3-row keyboard, which limited the character capacity. Remember the old messages where the actual word "STOP" was used because they did not have a period (or "full stop")? And the production costs needed to be reduced by cheaper and lighter parts, especially for the Armed Forces.

Teletype VP of Engineering John Auwaerter was coincidentally just at the start of planning a new system when X3 came into being. He saw the value of both a) hitching a ride, and b) influencing where the ride would go! He eventually chaired X3 for most of its early and most productive life. And for being so forward-looking he got the first ASCII-based hardware into production long before anyone else did.

IMPETUS FOR FEWER CHARACTER SETS

Facilitation of Fewer Character Sets -- Software

FORTRAN, being so successful, was moved to other computers. Then people were faced with program and data transfer to different computers. But those other computers would have to have all of the FORTRAN characters.

Facilitation of Fewer Character Sets -- Hardware

If you tried to transfer the program or data between machines, say by punch cards, you might have to repunch the cards for a specific computer, for the holes differed in size, shape, and encoded combinations.

If you tried to do so by using mag tape, the binary combinations representing the character set differed widely between machines. Admittedly most of these had 6-bit characters, but along came Stretch, with 8-bit characters.

If you tried to do so by using wire communications, there weren't any suitable standards, as the SAGE project showed. This got the US Government thinking about networks and network standards for military computers. Thus leading to Fieldata.

In the U.S., the Electronic Industries Association etc. had groups trying to reduce the number of different codes. So did their UK counterparts. But all of these efforts were bent to a) input-output media, not a computer CPU set, and to b) 5- or 6-bit codes (sometimes even 4 bits).

IMPETUS FOR A MAIN COMMON CHARACTER SET

Other pressures came from constant improvements in computer design and components. And from ignoring competitor's products while building to outsell them.

Rebellion against Unnecessary Variation

The occasion that set me forever on the path to a common character set was when IBM decided to build a new computer to replace the IBM 705 in its line. They did it by having B. O. Evans, of the Endicott, NY operation, make a new design, temporarily called the 660, based upon the super-successful 650 model. Rex Rice, at the Poughkeepsie, NY operation, was to make a new design following the 705 itself, a model temporarily called the 750.

I had Tom Glans replicate part of "PRINT I", a system I had written for the 705, based upon the 750 specs. If this could be done fairly easily, then existing 705 customers could also easily modify their programs for the new machine, leaving their data files intact. With Tom's success, we supported the 750 as the successor for the 705. But, as I have told the story often, programmers were underlings at the time, and not permitted to attend decision-making meetings. Our choice was relayed via one Roger Bury, a manager of Education. He, unfortunately, got it backward, and said we had recommended the 660. That seemed like a good enough reason to the decisionmakers, and was the genesis of the IBM 7070 (Footnote 1).

I had argued with Evans that the 705 (and predecessor 702), having been built originally with magnetic tape as the major storage medium, had in its set a character known as "group mark", used for controlling writing on magnetic tape. I then argued that his 660 (then 7070) design had retained the two-decimal-character representation of the 650, and that for the group mark character to take its appropriate place in the 660 (for collating sequence reasons) it would have to fall between 18 and 19, and I could see no way to represent 18 and a half in two digits!

I never saw his reply. Company mail? He may have thought this as of no import then, for the dangers of embedding character set relations in software was apparently never considered until IBM found to its stunning dismay that the 360 series software would not, and could not, run in ASCII mode, even when the infamous "P-bit" was switched from EBCDIC to ASCII.

But this got me curious. Did any other inconsistencies occur in the character codes within IBM's family of computers? I was surprised to find NINE (yes, 9) character sets, with differences in both content and ordering, in IBM's line! I presented these findings to V.P. John McPherson, my mentor at IBM, often *in loco* my actual superior, for, as Herb Grosch reported in his first book, there was for a very long time no such thing as a formal, published and distributed, organization chart of IBM.

I emphasized the ire that customers could exhibit if a) they had to completely reorder their files for the new machine when they relinquished the old, or b) they had to reorder back and forth in case they kept the old machine, too. In IBM this was what you could call a real attention-getter.

A full survey of various (some 60) existing character code sets (not a single one identical to any other) was published in the Communications of the ACM [17]. Perhaps the manufacturers did not sit up and take notice, but the users of more than one type surely did, noting that their files could not be moved between computer types.

FN-1 In all other tellings of this story (e.g. [142]) there has been only my own word for it. But now the Web yields a story by Evans himself [151], in the Computer Museum Report, Summer of 1984, where he admits that "the 7080 was a semiconductor version of the 702 and 705 business systems. It was brought out because the new architecture 7070 business system had not done as well as had been expected. Customers that had 702's and 705's were not converting their programs to the radically different architecture of the 7070 ...")

Later, IBM used this same argument of vast expense for data file reordering as part of its spurious argument against ASCII, and therefore in favor of EBCDIC, and look at the countless billions that has cost the world.

Further Pressures for Code Regularization

That's how I got into the coding standards area, or rather how I got IBM into it. If, in the text following, you find too much first-person usage, I ask forgiveness, for despite any other contributions, a common character code for computers has been the biggest crusade of my life.

But how about the rest of the world?

All research shows that other groups were much aware of the need for coding standards, but at the input-output media level. Apparently no other person had been so bold as to propose to management, as I had in a 1959 November memo to V.P. John McPherson, a plan for a "single character set to be used by all future computer systems ... the code to be the external storage code as well as internal machine code." Naturally it was to be an 8-bit set. Perhaps no other company of the time was like IBM then -- one could propose a reasonably good course of action, and they would supply people and funds.

That may sound odd today, but it happened for me three different times -- with FORTRANSIT (the first FORTRAN follower), with COMMERCIAL TRANSLATOR (a COBOL progenitor), and with a standard 8-bit code, beginning with, and taking off from, STRETCH.

Future Design (8-bit Code Studies at IBM)

In the fall of 1959 a John Gosden (UK) showed up at IBM, making a side excursion to see me, Frank Williams, and Howard Smith -- the subset of my group that was working on standard and extended character sets. He got quite excited about what he saw, particularly the 8-bit set -- quite a novelty then.

He took this information back to the British Standards Institution, to which I was invited to show our work the next time I came to London, (1960 Feb 23-27, right after X3 was formed, but well before it had done anything visible). One BSI participant was Hugh McGregor Ross. We hit it off very well together (so much so that the code that was to become ASCII was first called the Bemser-Ross Code in Europe). This is the same Ross that was a main force in the early days of UNICODE.

The Reader's Digest of 1961 June (origin Kiwanis Magazine) said that Bemser headed a group of programmers devising languages by which "machines can talk with machines - languages that will facilitate the exchange of information, by radio, microwave, or telephone wire between computers at widely separated centers ..."

PLANNING THE ASA X3 COMMITTEE

In the late fall of 1959 I was called to the office of IBM Vice President Jim Birkenstock. Vice President John McPherson was also there. Birkenstock told me of his plan to revitalize the old (and a bit moribund) Office Equipment Manufacturers Institute, refurbishing it into a group called the Business Equipment Manufacturer's Association (BEMA), to be the sponsor for American Standards for computers and information processing. Even then they may have had Charlie Phillips in mind to run it, for the COBOL steamroller had made an impression upon IBM.

I was told to create a scope and program of work statement for this effort. A strong impetus for this was my survey [17] (Tables 1a and 1b), showing 65 different ways that various computers were at that time encoding and representing the Roman alphabet and associated symbols (including IBM's variants), and the corresponding card code survey [18] (Table 2). In short, none of these computers could or would be able to talk to each other! Babel!

I speculated at the time about whether this action came as preventative to continuing antitrust actions by the U.S. Government against IBM, and whether this was to showcase IBM as really the good guy. I put this unkindly suspicion aside, however, not only because it gave me what I wanted to see done, but also because it was obvious that it just created a still larger pond for IBM to swim in, much to their advantage. Which was a perfectly ethical thing for IBM to do. Birkenstock made no mention of this in his memoirs in these Annals, but I have a marked-up FAX from him which confirms.

I do, however, remember instructions to always keep a passive stance in whatever I did, and not exert IBM force in or on standards that ensued. Which is why this paper, after four decades, can be much more revealing, now that a wonderful result has occurred.

THE FOUNDING OF ASA COMMITTEE X3

The ASA meeting in New York was on January 13 of 1960. I had not only prepared my draft scope -- I had some influence on attendees. I had Mandy Grems, who also worked for me, as the ACM representative, for she was active in glossary work. Bill Schilling of IBM Office Equipment, my next-door neighbor in Connecticut, represented that end. I think that I represented CODASYL. I drew these from a punch card database of all other IBM personnel involved in standards work that I had compiled and printed out on yellow Teletype paper. Other IBM employees attended under various auspices, like IEEE. Representatives of other concerned bodies and organizations attended. J.A.N. Lee gives a list of attendees in [152].

The scope and program of work for a computer standards body that I had drafted at Birkenstock's direction was adopted without demurrer. It was in six parts, and each had a subcommittee with that part for its goal and program of work. As planned, BEMA was authorized as overall sponsor for the work.

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Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
-																																					
. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
G H I J K L M N								O P Q R S T								U V W X Y Z																					
g h i j k l m n								o p q r s t u v								w x y z																					
Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
-																																					
. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
G H I J K L M N								O P Q R S T								U V W X Y Z																					
g h i j k l m n								o p q r s t u v								w x y z																					
Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
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. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
G H I J K L M N								O P Q R S T								U V W X Y Z																					
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Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
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. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
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Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
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. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
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Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
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. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
G H I J K L M N								O P Q R S T								U V W X Y Z																					
g h i j k l m n								o p q r s t u v								w x y z																					
Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
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+ J K L M N O P								Q R								S T U V W X								Y Z													
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+ J K L M N O P								Q R								S T U V W X								Y Z													
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. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
G H I J K L M N								O P Q R S T								U V W X Y Z																					
g h i j k l m n								o p q r s t u v								w x y z																					
Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
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. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
G H I J K L M N								O P Q R S T								U V W X Y Z																					
g h i j k l m n								o p q r s t u v								w x y z																					
Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
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. A B C D E F G								H I J K L M N								O P Q R S T								U V W X Y Z													
G H I J K L M N								O P Q R S T								U V W X Y Z																					
g h i j k l m n								o p q r s t u v								w x y z																					
Q R S T U V W X								Y Z																													
+ J K L M N O P								Q R								S T U V W X								Y Z													
-																																					
. A B C D E F G								H I J K L M N								O P Q R S T								U													

Table 1b (from Reference 17)
1960 Survey of Coded Character Sets

[illegible][illegible]

Table 2 (from Reference 18)
1960 Survey of Punch Card Codes

The salient part, though, covered a character set to be common to the entire effort. The division was:

- X3.1 -- Character Recognition
- X3.2 -- Coded Character Sets
- X3.3 -- Data Transmission
- X3.4 -- Common Problem-Oriented Programming Languages
- X3.5 -- Definition of Data Processing Operations, Terminology and Glossary
- X3.6 -- Data Processing, Problem Description and Analysis

This paper is obviously concerned with the actions of X3.2, for which my program of work [152] read:

"To develop a single standard for logical representation of characters and character format in the media used for interchange of instruction, data, and control information between data processing equipments, together with orderly provision for expansion and alternatives..." (Footnote-2),

I report with satisfaction that this guide has held up well for at least four decades, and that the "expansion" may be seen in UNICODE, and the "alternatives" may be seen in the ISO registry [157], which is very worth taking a look at if you have never seen it before. That is what regularizes the display of non-Latin characters on your screen and on your laser printer. Thus making the Worldwide Web *worldwide*. This is probably because the wording was subsequently adopted by all (inter)national and standards committees taking part in the selection of character content.

Herb Bright's Plan

As input to X3, Howard Smith, Frank Williams, and I wrote and published a paper called "Design of an improved transmission/data processing code" [21]. An interesting twist to this was that it came out when the X3.2 committee had hardly gotten in gear, with Howard Smith as representative for IBM. Herbert Bright, Standards Editor for the Communications of the ACM, wrote a letter to all, arguing that a lot of unnecessary work could be saved by adopting that proposal as the end-product code.

Here lies the answer to ASCII acceptance. Had I gone along and supported this proposal as an IBM plan, we may not have had ASCII today. Each manufacturer had his own customers' investment in data stored in order on THEIR internal code, and would have rebelled totally if they thought IBM had done this deliberately and had already converted. They needed an "escape" hatch, which was the original motivation for the escape sequence idea. [10]

FN-2 This "orderly provision for expansion and alternatives" is to my knowledge the first public proposal for sets alternate to the primary set.

Escape Sequence

Originally the escape character and escape sequences were the most important lure to getting the ASCII code adopted for interchange purposes, because manufacturers could assign an escape sequence to their existing internal codes, and continue to operate with their programs and databases intact until an easy and full transition could be made.

This would work because "escape", a character that never existed before, when followed by a preassigned group of other characters (an "escape sequence") changes attributes and meanings for all subsequent characters until another such escape sequence or a delimiter is encountered.

Later, after video screens came into general use, "escape sequences" were assigned to change the display attributes -- foreground and background colors, font styles, size, shape, and weight, alphabets of the world's languages, and cursor positioning. Much the same sequences are used to control laser printers.

Escape sequences are vital to the mechanics of HTML, and to the "orderly provision for expansion and alternatives" of the original program-of-work statement. Escape, now one of the most frequently used characters in the world, is also strange because it is invisible.

By avoiding telling IBM too much about its capabilities, it was effectively put into the public domain, via [10].

Demise of Bright's Plan

IBM needed to have the involvement of others, so that at the end the others could feel that they knew all about the interior workings, and that no traps were buried. It was thought that once they had twiddled with the assignments for some years they would have to, to damn ASCII, damn themselves as de facto authors.

So I didn't jump at Bright's plan, and I talked people with incipient agreement out of it. Big money was involved, and all competitors had to be convinced that the end product was the best they could conceive. Fruition took many more years, but at least the tree wasn't cut down.

Working to a Final Form and Adoption

I did the story of this rather carefully in an article for the Honeywell Computer Journal [140], and upon review can find no significant faults with the verbiage. So, with the permission of the author (me) and the Editor (me), much of it is cannibalized here, because copies are hard to find.

If the limning of IBM's actions seems harsh, remember that IBM has had 30 years to make objection, or set the record straight, as they see it. No such action is on record.

The 7-Bit Era Begins

After many unsuccessful months of trying to select 64 characters satisfying requirements of both data processing and communications, X3.2 finally settled upon a 7-bit set at its 1961 Jun 07-09 meeting. The alphabet was pushed to the bottom of the second column, as inherited from Fieldata. Yet the US Department of Defense was beginning to get concerned about conflict with Fieldata. Secretary Macon, in his summary report of the first 9 meetings, suggested that the code be called Fieldata No. 2, to give that credit.

IBM continued to be concerned about aspects of international compatibility. Two sets had been presented at the June 09 meeting with the Department of Defense - one with the alphabet at the bottom, and one with the alphabet starting in the second position, as now. This second condition was furnished by Ross, for BSI.

At its next meeting X3.2 had to decide between these two proposals. My study of the Copenhagen phone books showed a vital need to have at least 3 extra positions following the 26-letter alphabet, the accented letters following in these positions. I took this position strongly in the ensuing argument (which, although vociferous, is not indicated in the minutes). Placement of the special symbols was another matter; the traditional IBM collating sequence was specials (S), alphabet (A), digits (D). I had a ready solution -- the major special symbols (particularly "minus") were to be taken out of the digit column and placed in the previous column. For ordering purposes, the digit column could then be made to collate higher than the alphabet (for IBM's needs) by passive logic of bit inversion. The specials following the digits had not appeared previously in key fields used by IBM customers, and it did not matter if they were high to the alphabet. The 4-bit subset was thus constructible with a 4-position jog, or displacement. This was also important to IBM, for the packed decimal notation in the new line.

On this basis, John Auwaerter and I prepared a presentation that convinced X3.2 to settle the code in its present structure (Footnote-3); the basic 7-bit standard was agreed -- the alphabet (then upper case only) starting in the second position! The draft then stood as in Table 3, column 2.

I had called a joint meeting of IBM, SHARE, and GUIDE on 1961 July 06, to regularize the IBM 6-bit set to become the standard BCD Interchange Code [31]. Frequency studies of symbol occurrence had been prepared, particularly from ALGOL programs.

FN-3[167] contains my first written public statement about shaking hands with John Auwaerter to seal the just-agreed current form of ASCII. It was not recounted publicly until then, lest antitrust considerations were invoked. IBM was the big dog then, and I was IBM to the character set world of the time.

col.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
document	X3.2 to DoD	X3.2	RWB	X3.2/1	TC97 WG B	TC97 WG B	X3.2/4	ISO #1	STD X3.4 -1963	ISO #2	ISO #3	X3.2.4 /64	CCITT	X3.2 /172	X3.2 /206	ISO #4	ISO DR 1052	X3.2 /384	X3.2 /411
date	1961 06 29	1961 09 14	1961 09 18	1961 11 10	1962 05 04	1962 05 04	1962 05 25	1963 01 01	1963 06 17	1963 12 12	1964 05 05	1964 10 20	1964 10 09	1964 12 03	1965 01 21	1965 03 03	1966 04 04	1966 05 20	1966 07 15
0/0		NULL																	
0/1		RU																	
0/2			VT	SOM	EOT	SOM													
0/3			rcv 1 on	m off	EOM	EOA													
0/4			rcv 1 off	RU	EOA	EOM													
0/5		WRU			SOM	EOT													
0/6		motor 1 stop	tmt stop	EOT	WRU														
0/7		VT	feed out	HT	RU														
0/8		HT	feed out	FF	BELL														
0/9			motor stop																
0/10			rcv 2 on																
0/11		BELL			FF	FE ₀													
0/12		rec 1 on			VT	HT	(sk)		(sk)										
0/13		rec 1 off			LF	NL	LF												
0/14		rec 2 off			VT	FF													
0/15		rec 2 on			CR														
1/0					LC														
1/1					SI														
1/2																			
1/3																			
1/4																			
1/5																			
1/6																			
1/7																			
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1/9																			
1/10																			
1/11																			
1/12																			
1/13																			
1/14																			
1/15																			

Steps in the Evolution of the ISO Code

col.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
document	X3.2 to DoD	X3.2	RWB	X3.2/1	TC97 WG B	TC97 WG B	X3.2/4	ISO #1	STD X3.4 -1963	ISO #2	ISO #3	X3.2.4 /64	CCITT	X3.2 /172	X3.2 /206	ISO #4	ISO DR 1052	X3.2 /384	X3.2 /411
date	1961 06 29	1961 09 14	1961 09 18	1961 11 10	1962 05 04	1962 05 04	1962 05 25	1963 01 01	1963 06 17	1963 12 12	1964 05 05	1964 10 20	1964 10 09	1964 12 03	1965 01 21	1965 03 03	1966 04 04	1966 05 20	1966 07 15
2/0																			
2/1																			
2/2																			
2/3																			
2/4																			
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5/15																			
6/0																			
7/11																			
7/12																			
7/13																			
7/14																			
7/15																			

Table 3 (from Reference 140)
Steps in the Evolution of the ASCII Set

The meeting produced general agreement on a basic 60-64-character set, which included the two square brackets and the reverse slant, or backslash, which was chosen to be used in conjunction with "/" to yield 2-character representations for the AND and OR of early ALGOL. This is reflected in the set I proposed to X3 on 1961 September 18 (Table 3, column 3), and these three characters remained in the set from that time on. The lower case alphabet was also shown, but for some time this was resisted, lest the communications people find a need for more than the two columns then allocated for control functions.

At its 1961 Nov 08-10 meeting, X3.2 constructed the first formal proposal, X3.2/1 [23] (Table 3, column 4), with explanations for its structure and content, including the compatibility with Europe, where the UK standard was at the printers! The arrows were moved up so as to be expendable when replaced by single symbols 10 and 11 for pence in the English monetary system of that time.

Going Truly International

The Americans, less accustomed than now to international standardization work, had their eyes opened at the first ISO/TC97 meeting on 1961 May 15-19 in Geneva. At the 1961 Fall Joint Computer Conference, on 1961 Dec 11-12, I had broached the possibility of direct discussions at working level to Philippe Dreyfus of ECMA. This was discussed at the concurrent meeting of X3.2 on 1961 December 11-13. Dr. J. Barker of BEMA, chairman pro tem of X3, was irate with such lack of national loyalty. Nevertheless, X3.2 Chairman Charles Macon announced that it was arranged for Bloom (of NCR) and Auwaerter (of Teletype) to go to Europe for the period of 1962 January 02-22. The resulting frank discussions with BSI and ECMA had very good effect. On January 29, X3.2 received from Hugh MacGregor Ross a proposed compromise that could meet the requirements of ASA, ECMA, BSI and the EEA (Electrical Engineering Association of the UK). Thus all necessary groundwork was laid for the first meeting of ISO/TC97's Working Group B on 1962 May 04.

Henri Feissel of BULL was elected chairman. Present were delegations from France, Germany, Italy, the UK, and the US -- plus ECMA and the UIC (Union Internationale des Chemins de Fer). Yes, trains! Despite the official UK position for its own standard, Ross put forth his compatible proposal. Although Germany wanted to move the alphabet to start in the very first position of its column, there was considerable agreement, and a 6- and 7-bit code were resolved. The latter was in two versions, A and B (Table 3, columns 5 and 6), differing only in the two control columns. Germany preferred A, all others preferred B.

The great significance of moving the work to the ISO level is evidenced in these proposals, noting how many choices remained fixed after this time. Furthermore, the controls were regularized and grouped to 7 transmission controls, 6 format effectors, and 5 device controls; the improvement from the haphazardness of the previous proposals is quite apparent.

It was noted subsequently that the positions of ":" and ";" were unsuitable for pence replacement in sterling. Cooperation was so well established by this time that interchange with "*" and "+" was effected by a telephone call to ECMA in Europe, who confirmed its agreement to WG B on 1962 June 27.

There were a plethora of such swaps, changes, and additions to the roster of characters, and where they were assigned in the table. The history of this flux is shown in Table 3, where the column headings identify the proposals.

X3.2, whose written vote on X3.2/1 was all affirmative except for IBM † and an abstention from ITT, proposed to X3 that the new document, X3.2/4 (Table 3, column 7) [26] be supported, as there were minor changes. International consistency with Proposal B was stressed, and X3.2 recommended extending the X3 ballot period to 1962 September 15, as WG B needed official opinions for the 1962 October plenary meeting of ISO/TC97.

There followed a difficult period in the US, eventually leading to the first American Standard Code, X3.4-1963.

This Player is Benched

In 1961 August I had been moved under T.V. Learson's (Footnote-4) jurisdiction, from Manager of Corporate Logical Systems Standards to Director of Programming Standards, reporting through Bill Andrus, IBM Director of Standards and a close personal friend. Learson then got rid of me by shipping me off to Research in early 1962. Andrus said later that the reason Learson gave to him was that I was "giving the store away" by cooperating too much with ANSI efforts on ASCII. Not being much of a research type, I rebelled by leaving to run the software operations at UNIVAC.

Jim Birkenstock now names John Rankine, successor to Andrus, as the best ever Director of Standards for IBM. Rereading the history, there is no question but what Andrus followed Learson's desires and direction to the letter in opposing ASCII as it developed and was eventually adopted. It may be that Birkenstock now sees that opposition as a bad move, seeing how ASCII has turned out well and facilitated many great advances in computing. But even had Andrus joined me in objecting to Learson's tactics (which sent me to what IBM called the "penalty box", I doubt whether he could have been overridden in his eventual error in opposing ASCII via the EBCDIC route.

FN-4 T. Vincent Learson, IBM Vice President 1954-, Senior Vice President 1964-, President 1966-, Chairman of the Board 1971 June to 1973 November (source of information - official IBM Websites.)

GETTING AN AMERICAN STANDARD CODE

The original negative vote of IBM on X3.2/1 (at the X3.2 level) was cast by a Robert Blue, who had replaced H.J. Smith, Jr., as the IBM representative. Smith was asked, however, to remain as a consultant to X3.2 in recognition of his many fine contributions (as supported by Berner and Frank Williams). This was permitted by IBM, with the explanation that

† *"We have tried to participate ... according to ASA rules, and have allowed our participants to act freely on a purely technical and professional basis. Since the actions of our participants have been construed as company actions and endorsements, we shall, in the future, ensure that these are one and the same ..." (IBM's Bartelt to Macon on 1962 March 02).*

Accordingly, Blue's negative stated that:

† *"IBM studies have shown that the proposed 7-bit code with its contiguous alphabet would be expensive to implement in the present domestic data processing environment oriented to the use of 6-bit processors and punch cards."*

No mention was made here of the fact that IBM intended to change that environment with new product lines having 8-bit processors (i.e., 8000 and 360) and a collating sequence that would demand considerable reordering of those punched cards!

William E. Andrus, Jr., IBM Group Director of Standards, reporting directly to T. V. Learson, had the awkward task of trying to explain IBM's negative vote to X3:

† *"After extensive study of the entire problem of code standardization, this investigation, together with the experience gained during our many years in the data processing field, indicates that the benefits derived from the adoption of this standard would not justify the economic burdens involved with its implementation. We submit that the BCD Interchange Code [31] is, and must be formally recognized as, a standard because of its wide use both in punch cards and magnetic tape ... IBM supports the development of standard codes (sic plural) for information interchange, but will not support any proposal for a single standard code. X3.2 should consider the possible interaction of future 8-bit codes on present standardization activities."*

ITT Communications Systems also took a negative position. A 1962 June 18 paper by L. A. DeRosa said that "The proposed code standard ASCII is considered unsuitable as a standard". (It wasn't Fieldata).

As decisions moved from the technical realm to the administrative levels of X3 and the BEMA Data Processing Group (DPG), support lessened. Friden said it must vote negative because terminal costs would be increased 30% to support ASCII (but they presented no data). Many minority position papers were written, and X3.2 made extensive and detailed replies to the (some less than rational) objections. The paper of Blue (IBM) and Ungar (ITT), for example, observed that "positive numbers would collate lower than negative numbers". X3.2 took 2 pages to prove that, no matter what positions were assigned to + and -, it is still impossible to order numerals with a binary sort!

Another objection was that it would cost \$124 million and take two years to change just the Fielddata 465L computers, a position not supported by their owner -- the U.S. Dept. of Defense. Thomas D. Morris, a U.S. Assistant Secretary of Defense, wrote X3 on 1962 August 06 to say that "This office is wholeheartedly in support of the ASA Sectional Committee X3 standards development effort both domestically and internationally". He recognized the differences with, but similarities to, Fielddata in organization and structure.

On 1962 July 29, Lin Griffin, now chairing X3.2, informed the Chairman of X3, Charles Phillips of COBOL fame, that X3.2 had approved (by majority vote) a motion that none of the minority positions nor the negative or abstaining votes were deemed necessary or sufficient reasons to warrant revision of the proposed ASCII [26]. "The subcommittee reaffirms its belief that the proposed standard code is the best code it can develop for information interchange purposes, and has the best chance of acceptance and implementation on a national and international basis".

On 1962 August 17 IBM abandoned protection of the 6-bit code and exposed a paper by its Charles Mackenzie, "The construction of 8-bit coded character sets", to the BEMA DPG, and to X3.2 on the following August 22. Here it was admitted that although the IBM Standard BCD Interchange Code did not have binary collatability embodied, this proposal did.

In short, IBM furnished [128] the prototype of the EBCDIC (Extended BCD Interchange Code). X3.2 rejected it by a 7-1-1 (yes-no-abstain) vote. "Since it is based upon a structure which was rejected earlier by X3.2, the subcommittee does not recommend revision or withdrawal of X3.2/4."

IBM then asked for an evaluation of economic impact, which was rejected as having no precedent in the records of ASA. At the 1962 September 10 meeting of X3, postponed by Phillips from August 21 because of what he felt was a current lack of consensus, X3 voted to send Document X3.2/13 (containing editorial revisions to meet requirements of X3.3 for data communication, thus changing the AIEE vote to affirmative), to ASA for approval. The vote was 20-4-5, with the incognito vote of the BEMA members allocated 6-2.

At this point one might expect that the standard would go to ASA for processing and publication, but there were several more hurdles. First was the BEMA DPG, sponsor of the X3 work. Andrus of IBM wrote this group on 1962 October 11 to say:

† *"We find it necessary to continue to abstain from voting on the X3.2 code until our request of August 17" (for the IBM code to be named a de facto standard) "is acted upon. ... Be assured that if BEMA will not act upon our requests, and if the X3.2 code is issued as an American standard by ASA, IBM will cooperate, making the code available where the economic disadvantages to IBM customers are not a factor."*

If we are to have taken IBM's promise seriously, it should be noted that such economic advantage took some 17 years to surface, with the IBM PC!

On October 31 the BEMA Standards Review Board (probably newly constituted, as it had never been heard of before, and its membership by individual is unknown to this day), voted 11-3-3 for forwarding. Nays were from Friden, Addressograph-Multigraph, and Monroe, all of whom were represented on both X3 and X4. (X4, Office Machines, chaired by MacFarlane of IBM, had objected to the code as it might apply to office equipment, but decades later the laser printer manufacturers make no such complaints). Abstentions were from IBM, Moore Business Forms, and Smith-Corona-Marchant. The RCA position was unknown, but manufacturers voting yes included Honeywell, Burroughs, NCR, and UNIVAC.

On 1962 November 05, X3 member Frank White of the Air Transport Association wrote to ask BEMA:

† *"Rumor has it that BEMA has turned down the recommended action of X3 relative to the standard code for data processing. Do you plan to provide ... details ... so that we may take under advisement what may be done to achieve effective implementation of the policy we recommended?"*

Phillips replied that:

† *"The BEMA Standards Review Board decided to defer the transmittal of the proposed Standard Code for Information Interchange until something further could be done toward achieving a consensus. The Board also recommended that X3.2 take appropriate action to submit de facto standard codes concurrently with the pASCII (Proposed ASCII). It is believed that such actions would satisfy the objections raised by the X4 Sectional Committee."*

Phillips further notified the Joint Steering Committee of X3, X4, and X6 that

† *"The Sponsor requests that X3 and X4 propose a de facto standard or standards for consideration concurrently with proposals for pASCII expressed in media".*

Phillips then wrote to Roger Gay, ASA President, on 1962 December 05, saying:

"The problem here is one of attempting to introduce a new and nonexistent code convention as the first and only standard in the character code field of information processing systems. Such an action would render widespread de facto code practices 'nonstandard' and obsolete, with potential economic and technological hardships to at least the suppliers of equipment affected by such standardization."

X3 was informed of the sponsor's actions as of this date. X3.2 was as distressed as X3. At its 1962 December 05-07 meeting, a motion passed 5-2-3 that "X3.2 is of the opinion that if any existing coded character set is to be considered a de facto standard, many must be considered, and that, if any one (set) is found allowable jointly with the pASCII, many will be found allowable ... Analysis of documents [17,18,20] supports this position".

Griffin then prepared a summary memo for the Joint Steering Committee, dated 1962 December 18.

It remained to Roger Gay of ASA to be the upstanding and experienced statesman. He replied to Phillips on 1962 December 21:

"It is my understanding that ... each of the existing codes had serious shortcomings which precluded its being recommended ... the Constitution of the ASA specifically prohibits the promulgation of conflicting standards ... In X3, however, there was never a formal recognition of any of the "de facto" codes, and the very insertion of such codes in the American Standard may promote their continued use rather than urge their discontinuance. In other words, you would be maintaining the status quo which has been greatly criticized in the past."

Gay noted that James Birkenstock, V.P. of IBM, had said that "IBM believed industry as a whole stood ready to cooperate in coming up with a single language". † But Gay did not say whether Birkenstock had said that before or after Learson had taken the controls from him.

Gay also said that William Suchors, V.P. of Remington Rand "too felt that all manufacturers could harmonize their thinking in the new project".

He then reminded BEMA that

"at all levels, the views of the sponsor are taken into account. However, the sponsor has no veto power".

He advised calling a meeting, and that

*"if the decision of X3 is that de facto codes should **not** be added, BEMA should transmit the pASCII without delay to ASA".*

The Underwood Corporation accented the anomaly by writing to ASA that they were against the inclusion of de facto standards, but if there were to be any, here was theirs! Others took frontal action. Paul Riley, Deputy Asst. Secretary of Defense, in his 1963 January 18 letter to Phillips, urged approval of ASCII, particularly to put the US in a better position at ISO. G. D. Osborn, of the Executive Office of the President (Budget), wrote X3 members that it was important that the proposed code be forwarded to ASA and adopted now.

At the 1963 January 24 meeting of X3 it was voted, by a 2 to 1 majority, to transmit the pASCII directly to ASA without recommendation of the sponsor, the first (and perhaps only) time such an action had occurred in the history of the American Standards Association!

In a final attempt, Phillips wrote to Gay on 1963 February 08, saying:

† *"It appears that a part of the action ... of October 31 was in conflict with this interpretation of ASA regulations ... the sponsor's new recommendation on the pASCII was developed as ... 'the sponsor accepts the principle of a single code for information interchange.*

This code will be universally useful only when it can be adapted to the common methods of machine-to-machine communications, i.e., paper tape, punched cards, and magnetic tape. The sponsor, therefore, believes that submission of the pASCII to ASA is premature'."

This position, adopted by a 12-3 vote of the BEMA Standards Review Board, was ineffective, however. Standard X3.4-1963 [36] (column 9) was approved by ASA on 1963 June 17, after a hearing by its Miscellaneous Standards Board. As a note on how times have changed, ASCII today does not appear to be miscellaneous! And paper tape usage is at an all-time low!

ANNOUNCEMENT TO THE WORLD

Business Week Magazine

The action was newsworthy. Ted Merrill of Business Week Magazine, a professional writer who had followed the work pretty carefully, made a significant point [35] when he said that "ironing the kinks out of pASCII took about \$3 million worth of man-hours". He noted that AT&T was one of the earliest to gamble, with its new Teletype line [45] (Footnote-5), and that "some equipment manufacturers, notably IBM, agree that the basic code is a good one, but would like to wait and see how it will be standardized for punch cards before they give their stamp of total approval".

FN-5 Teletype had gambled quite well. The upper-case-only Model ASR-33 was introduced for sale in late 1962. And it was not more than a month after ASCII was adopted when a Teletype Model 33 was delivered to me at my temporary office at Computer Sciences Corporation in El Segundo, California, so I could communicate with the dual-case Teletype Model 37 at my office in New York City!

He suggested that "many computers will undoubtedly use it as their own internal language to avoid the translation problem altogether". (Footnote-6). Adoption of the ASCII was occasion for a number of other articles that publicized it [37,40,42,45].

Datamation Magazine

The exhibits that follow show the pages of my article about ASCII in Datamation Magazine [37], the second exposure. It isn't all that technical, for it seemed more important to emphasize all the strategies and reasons for its acceptance. It was probably the first standard not derived from accepted practice, which was a big departure that needed to be made friendly and wanted. Thus the stress on:

1. No demand or plea that manufacturers use it as an internal code,
2. We'd be happy if they just thought of it as for interchange, and
3. Here's an easy mechanism, in the form of the escape sequence, to do just that without clobbering your present ways of operation on your existing files.

I.e., the Escape Sequence concept could be viewed by all manufacturers as THEIR escape hatch -- assign a sequence that meant COMPUTER TYPE "Theirs", and they could live with ASCII while it got established.

As further argument and inducement, committee development had been used, not primarily to define and construct ASCII, but to give users the warm fuzzy feeling that they could accept this new departure because they had a hand in tweaking the definitions and results.

The "II" in "ASCII" was stressed critically. "Information Interchange". The "star" diagram was prominent. One could still use all one's own data in the old proprietary code, but to talk to others who did not normally run in ASCII over communication lines, a 1-1 translation was necessary.

What was not stressed was the opinion and hope of several participants that eventually they would get tired of that, and new equipment would be ASCII-based as far as program logic went. At least that was the way IBM was thought to be going to play it.

I have always felt indebted to Datamation Editor Bob Forest for selecting me for this writing task.

IBM Proprietary Publication

A special issue of IBM's Data Processor [38] was devoted to describing the adoption of ASCII and its import.

FN-6 Eric Clamons, longtime worker in X3, was the product planner for the UNIVAC 1050. Our joint determination made the 1050 the closest thing to an ASCII machine until the earliest personal computers were fitted with ASCII.

To support ASCII ... IBM plans to provide whatever means are practical to meet customer needs for using the standard code as soon as possible, after media standardization is approved by the American Standards Association. Because standardization is so important, we have already begun to implement ASCII ... We as a corporation are determined to move ahead with ASCII at the most rapid pace possible so that our customers can gain the benefits of standardization across the industry ... "

The Era of Cooperation and Goodwill

Harry Cantrell, the General Electric representative on X3, reported that "IBM's activity in this standards work, its position papers, and its votes on various questions all point to a clear IBM intention to announce ASA-standard code equipment at an early date ... we can expect IBM's forthcoming 8000 line to be ASA compatible, featuring 8-bit bytes internally".

Indeed, when I left the action at IBM around February of 1962 (involuntarily, having been shipped to Research to work under Herman Goldstine), it had been my impression that the new 360 line would be primarily ASCII-based computers, still handling the ordering of existing BCD files. These files (not previous programs) were the only obstacle to ASCII -- there was *no way* that programs for *any* previous IBM computer would run on the new 360 line, without an emulator, and possibly not even then (in its primacy, IBM had many people that thought they could overturn natural law with executive power).

All my efforts in this direction seemed supported by the IBM management I knew, until Learson. Hadn't IBM itself (via Birkenstock) caused creation of the mechanism for the development of ASCII -- BEMA, ASA and X3? Hadn't they supported me and my group in developing the first proposals for an ASCII-like code? Hadn't they sent me to Europe to talk to the British Computer Society, to the British Standards Institution, and to encourage the formation of ECMA, a similar standards body with no known subservience to IBM interests?

The heartening face of cooperation was welcomed by everyone, for ASCII was consonant in every aspect with the First Draft ISO Recommendation of 1963 January [32] (Table 3, column 8). The ISO Draft did, however, maintain the 6-bit set with equal status, which was reflected in the adoption of ECMA-1, a 6-bit set [33] in 1963 March.

ISO/TC97/SC2 held its next meeting in 1963 October, at which time it was decided to add the lower case alphabet. The Second Draft Recommendation [46] (Table 3, column 10) gave more consideration for international alphabets; thus the single quote of the US gave way to accent acute, and the arrows fell to accent grave and circumflex, while underline was added. Format Effector 0 was definitely made Backspace, completing the necessary preparations for diacritical marks (remember that this was before HTML). One resolution at this meeting contained the unanimous recommendation that this code be adapted for Numerical Control usage.

In preparation for the 3rd meeting of SC2 (formerly WG B), X3.2 was advised that the "at" symbol was wanted as an additional national use position, which implied a trade with underline. This was tentatively agreed. Also proposed was the replacement of RU by ACK, and ERR with NAK.

SC2 meeting No. 3, held in New York City on 1964 May 12-15, was relatively uneventful, except for the presence of a Japanese delegation of five, headed by Prof. H. Wada. All proposed changes were approved, and ESC was moved to its final, current position. The revised proposal was to be circulated as the 3rd Draft [48] (Table 3, column 11), and sent to CCITT (Consultative Committee International for Telephone and Telegraph). Ad hoc groups were formed for implementation in media, but SC2 would not accept the bit-to-track assignment proposed by the US for magnetic tape, because they had not done any work on it (an 8-bit world was just now seeming real, with the announcement of the IBM 360).

The liaison with CCITT was significant. Its Study Group Special A had been considering a new alphabet since its 1958 meeting in Warsaw. At the 1963 May meeting in Geneva, CCITT endorsed the principle of the 7-bit code for any new telegraph alphabet, and expressed general but preliminary agreement with the ISO work. It further requested the placement of the lower case alphabet in the unassigned area.

To match the 3rd Draft Proposal, X3.2 adopted Document X3.2.64/64 [61] (Table 3, column 12) on 1964 October 20, not knowing that CCITT had met in Moscow on 1964 October 06-09 to study the ISO proposal as a working alphabet. CCITT made certain other changes for natural languages, replacing reverse slash by tilde, and adding a universal currency symbol (Table 3, column 13). At the request of the USSR (which did not participate in TC97/SC2), accent grave was interchanged with underline to accommodate the 31-character Cyrillic alphabet [91], a consideration I had overlooked when arguing for room for 29 alphabetic characters for the Scandinavians).

When advised of this, X3.2 accommodated with Document X3.2.4/172 [63] (Table 3, column 14). In these last two revisions, however, added symbols for programming languages may be seen. In revising ASCII to remove all controls from column 7, Task Group X3.2.4 added (for the first time) the two curly braces, a vertical line, and a Logical Not symbol. The latter two were intended to accommodate the Logical Or and NOT functions of PL/I (obviously the committees still thought that IBM would tolerate ASCII).

During discussion, John Windhorst of CDC urged that the two PL/I symbols be put somewhere in columns 2 through 5, to keep the PL/I 60-character subset within the dense graphic set of 64 characters. His political wisdom did not prevail, which led later to the unfortunate usage of exclamation point and circumflex for these functions, so complicating an otherwise clean mapping to EBCDIC. In retrospect, all this resulted because programmers ignored my 1961 letter to the programming language people in ISO/TC9/SC5 [25], advising them to register escape sequence identifiers for the various programming languages. In other words, look at how natural languages coexist with ASCII today, without prejudice, on the World Wide Web.

X3.2 being ever accommodating, X3.2/172 was superseded by Document X3.2/206 [64] (Table 3, column 15) to match the 3-character symbol limitation of the new military standard [62]. This document carried an excellent summary of the various changes, with their justifications. However, it also carried a note that caused Univac to threaten a negative vote - "The resultant structure of specials (S), digits (D), and alphabetic (A) does not conform to the most prevalent collating convention (S-A-D) because of more demanding code requirements". This despite the fact that it is impossible to provide satisfactory orderings of upper and lower case characters by simple binary comparison.

The Dark Ages Again

The position and cooperation of IBM was a most important factor for progress of a standard code, and the System 360 (now that the 8000 series had been scrapped) was crucial to IBM's position. The 360 had been designed to handle both the Extended BCD Code [128] (for as much upward compatibility as could be achieved for former equipment and files) and also the eventual ASCII, when that became completely settled.

However, there was a lot of resistance in ECMA and X3 to an 8-bit code, and the fact that ASCII-based operation was not in clear sight when the 360 had to be announced, led to the decision to make EBCDIC the primary resa. One could imagine IBM reasoning that operation in ASCII could wait until all the code selections were settled, at which time the software would be modified slightly, the P-bit switched to ASCII internal mode, and everything would be fine!

Unfortunately, the software for the 360 was constructed by thousands of programmers, with great and unexpected difficulties, and with a considerable dearth of controls. As a result, the nearly \$300 million worth of software (costed at first delivery) was filled (even saturated) with coding that depended upon the EBCDIC representation to work, and would not work with any other!

Dr. Frederick Brooks, one of the chief designers of the IBM 360, and the person in charge of their software effort, informed me later that IBM had estimated a cost of \$5 million to provide a reworked set of software to run in ASCII. This 1.6% of original expense seems negligible. However, IBM decided not to do so, and from this time the worldwide position of IBM hardened to "any code as long as it's ours".

IBM Explains It All

On 1964 October 16, C.E. Mackenzie explained to GUIDE (one of IBM's two main user groups) IBM's plans for implementing ASCII in the System 360. He stressed the profound difference between supporting the development of a standard and supporting the standard itself, such as actually implementing it in hardware and software:

"IBM feels that its primary function is to supply equipment to meet the needs of the marketplace ... IBM will always make a businesslike decision ... the questionnaire distributed to all members of GUIDE at this meeting (and previously to SHARE) is one of the tools used to determine customer needs in the area of information interchange".

He noted that the changes and differences between BCD and EBCDIC "should not provide any *serious* problems for IBM customers", and that "IBM has been unable to determine any appreciable customer needs for ASCII on magnetic tape, or on punched cards, or on perforated tape as input/output for a computer". He went on to relate the low need for data communication with ASCII.

IBM's 360 WSSG Information Letter No. 17 (dated 1964 October 14) contained this illuminating verbiage:

"The choice between the two codes is determined by a mode bit ... a sharp difference between the two codes is the collating sequence. The EBCDIC sequence is consistent with that of previous systems and is therefore largely (sic) compatible with that of our customers' files. The natural ASCII sequence ... would place the numbers (sic) before the letters ... "

Thus it may have been unexpected to many that Jerrier Haddad of IBM moved, at the 1965 February 04 meeting, that X3 should support the revised ASCII [64] (Table 3, column 14) for concurrent letter ballot and publication. Meanwhile, the Fourth ISO Draft Proposal [67] (Table 3, column 16), as influenced by CCITT, was being circulated.

IBM gave X3 the results of its user surveys on April 22. Perhaps the standardizers were skeptical about Joe Datastore being able to foresee the future (imagine being asked, in 1970, whether you intend to transmit data via geostationary satellites?). So the June 10 vote for prASCII (the "pr" standing for "proposed revised") stood at 31-0-0. IBM's affirmative ballot on the ISO proposal suggested the vertical line as logical OR, and the tilde as logical NOT †. Auwaerter said this had not been discussed in X3.2, as the comments arrived after all other work was done, and commitments made to the other countries.

The US vote on the ISO Draft Proposal was affirmative, unanimously. At the September 16 meeting, X3 voted 24-0-2 to forward the prASCII to ASA, encouraging the U.S. Department of Commerce and the General Services Administration to solicit views on making ASCII a Federal Standard under the provisions of the Brooks Bill, Public Law 89-306 (which it finally did become in 1968, as "FIPS PUB 1" [108], signed by then President Lyndon Johnson.)

The voices of programmers grew louder, inversely with their understanding. (Footnote-7). Pressures for the two odd characters of the PL/I programming language continued, worldwide, and other pressures existed to put the "at" symbol back in the 64-character subset. Despite the express intent of many years, and rigorous interpretation of the meaning of "interchange code", one B.R. Faden proposed to SHARE, the IBM user group, that it should take a position with ASA for a study of an internal binary code. He said that "it would be a national calamity, truly national and truly calamitous, if ASCII is established as a standard for this purpose". This did not, however, prevent mini- and microcomputer designers from using ASCII as an internal code.

If Mr. Faden is alive today, it may be because he doesn't use a dangerous and calamitous PC! And perhaps he has noticed that PCs, and ASCII, are used by people other than programmers!

• A Promising Draft Recommendation

TC97/SC2 held its 3rd meeting in Paris on 1966 April 25-29. It was a momentous one, a landmark in the progression of ASCII to full acceptance throughout the countries of the world. Japan presented Document 163 on extension to non-Latin alphabets, both 7-bit and 8-bit superset [121]. USSR usage was reported as SO to Cyrillic [91], and SI to Latin.

To ensure full agreement, a joint meeting with CCITT, Working Group - Alphabet, was held concurrently. Commercial "at" and accent grave were once more interchanged, and the currency sign problem was alleviated, although not solved permanently, by assigning the pound sterling symbol to 2/3, with the number sign permissible for those countries that did not need the sterling symbol. SS (Special Sequence) was replaced by SUB (substitute character), and the overline (which could serve as a tilde) was put in 7/14. This produced ISO Draft Recommendation 1052 [76] (Table 3, column 17), for voting under accelerated procedures.

FN-7 1962 May 09: In [25], Bemer to the international programming language standards committee:

- *Is an "escape character" provided to allow for usage of alternate, specialized character sets? What graphic subsets should remain in common positions in alternate sets so that they be uniquely recognizable?"*
- *What values following the escape character ... should be reserved for specialized character sets for programming languages?"*
- *From the attached (proposed) IFIP definition of "escape character" it may be seen that it is possible to have many compatible alphabets within the framework of an international character set and code ...*

It is proposed that a tentative group of characters (to follow the escape characters) be reserved to indicate special alphabets for programming languages ..."

Point 2 pointed to registry, but the concept was too new and foreign to programmers.

The US position was not stabilized by these actions. Knowing in advance of the proposal to interchange "at" and accent grave, the Information Processing Systems Standards Board of ASA, ordered suspension of the printing of X3.2/206 [64] (Table 3, column 15) as Standard X3.4-1965.

The doors were in fact reopened. At the next X3 meeting SHARE argued that the rASCII did not meet pressing needs of the programming community, and X3.4 agreed. But X3.2 reported listening to these arguments and still approving X3.2/384 [74] (Table 3, column 18), reflecting the changes of the Paris meeting. After editorial changes to permit stylizing of certain graphics for logical operations, this document was sent for 30-day letter ballot.

Argument persisted, and X3.2, at its meeting of 1966 Dec 14, approved in desperation a modification to stylize the vertical bar by splitting it in two (Footnote-8), creating X3.2/411 [78] (Table 3, column 19). One X3 member, Doug Kerr of Bell Telephone Laboratories, discovered in his research that, according to the encyclopedia, the ASCII *"are those inhabitants of the globe which at certain times of the year have no shadow ... such are the inhabitants of the torrid zone; by reason the sun is sometimes vertical to them"*. Kerr observed that the inhabitants of the parallel 41°48' North, running through such cities as ... Poughkeepsie, NY, are never ASCII. Yet when balloting closed, both IBM and API (American Petroleum Institute), carrying the campaign for SHARE, had voted affirmative. At the next X3 meeting it was forwarded to ASA by 33-0-2.

At ISO/TC97/SC2's 4th meeting, again in Paris, the vote on DR 1052 stood at 10-3 (2 not received) for the P (Principal) members of TC97. Spain voted nay because the tilde was only in a national usage position! The vote of the full ISO membership was 13-3-6 (32 not received). So it was sent to the ISO Council, with only Japan voting negative because of the dual assignment of pound sterling and number sign (the currency symbol is still a thorn). The equivalent wording about stylizing for programmers was included. Thus it was a quiet meeting. For 15 resolutions times 10 countries there were 147 ayes, 1 nay, and 2 abstentions!

An International Standard

On 1967 December 22 the ISO accepted DR 1052 by a 12-1 vote (Ireland opposing). It was then published as ISO Recommendation 646 [97] (Table 3, column 17). It had the advantage of being entirely consistent with CCITT Working Alphabet No. 5. For the United States, it matched X3.4-1967, and also X3.4-1968, a Federal Government Standard [108]. For Japan it was consistent with JISCII [121]. And many other countries then had their national standards derived from it [91, 157].

FN-8 To me, SHARE's unwarranted uprising re special characters for the language PL/I was disgraceful. Their problem had been solved in 1962 [25], but they seemed deaf or ignorant. This was not a genteel movement in committee environment, but a full-scale street rebellion, fomented to revolution heat by propaganda devices. One wonders even now if the fomentor was IBM in hurt rage †.

ASCII IN MEDIA

We do not say that ASCII representation in media was not considered until the coding was mostly decided, but attention given to it increased as the contentions for the code decreased.

Looking at Table 3, counting the positions of the upper and lower case alphabets as two assignment decisions in a total of about 200 such, one could divide that number into the \$3 million that Business Week said was spent to develop ASCII, and conclude that it was a very high price per decision. But it isn't so. The second "I" in "ASCII" stands for "Interchange". And interchange occurs either by direct connection or by external media.

So all ASCII development wasn't just "which encoding". The assignments to media representation weren't easy to come by, either. Four types of media had to be converted to ASCII:

Interchange via Paper Tape

Here the variables were a) the number of tracks on each side of the drive holes, b) were the tracks assigned sequentially according to the columns of ASCII?, c) and if so, did the columns get assigned right to left, or vice versa? These decisions were fortunately and adequately taken out of committee hands by Teletype, in the person of John Auwaerter.

Interchange via Punch Cards

The hardware designers at IBM were probably all from Kansas City, where everything, according to the song, was up-to-date, and they'd gone as far as they could go! They had cleverly built in a filter that blocked the card reader from recognizing any hole combinations except those of the existing 48 characters, of which legal combinations were of any of three "zone" punches (12, 11, 0) and any of 0-9, plus an 8-punch if the other two were not 8. I.e., one could not add combinations of three or more punches, period!

A temporary dispensation was discovered by exhaustive tests, which the hardware designers themselves had not made. A few new patterns were found to work. But not enough.

Various other methods were explored for expanding the set of characters that could be entered via punch cards. Plain binary cards were one possibility, but the average user could not understand them visually.

But the keypunch could be prevented from moving to the next column position after the current column was punched. What if the card was kept in the same column position, and repunched with a different character? Now we could get up to 5 punches in a single column, and the card reader limitation could be bypassed by using the binary read option.

One proposal for this was published [6]. 2-character mnemonics for the characters would be punched in one column. Left parenthesis would be "LP", yielding 11-3 for "L", and 11-7 for "P", resulting in 11-3-7. This was of interest to Mackenzie in his book [149], but it was in actuality only intended as a spoof and attention-getter.

The combinations of holes, which in a single card column represent one character, had before ASCII been in as much of a shambles [18, 20] as the bit encodings were. At first the inclination was to start all over, making some direct connection between logical bits and the holes in the card, an approach known as "Decimal ASCII". It was ridiculously presumptuous to expect existing users to totally convert their physical inventory of punch cards, which at 2000 per cardboard box would be ~ 160K characters; about 1/8 of today's little diskette. So about 1967 Jan it was decided to just take the rough edges off the old mess, and augment it at random, resulting in [83].

Inasmuch as such cards have now largely disappeared, you might think this an unimportant matter. Not so. Eric Clamons of UNIVAC, then a to-be chairman of the working committee X3L2, argued and forced through the assignments for BOTH ASCII and EBCDIC (even though the latter was still proprietary) [83, 98, 109, 118]. These never got much external publicity, but they were shown in the ASCII chart accompanying the Honeywell Computer Journal article [140]. The significance is that this standard effectively tied together ASCII and EBCDIC in a complete 1-to-1 mapping. So, when IBM's ASCII-based PC was used as an I/O device for their EBCDIC mainframes, they had but to make an ASCII-EBCDIC-ASCII chip based upon a correspondence already defined by the punched card mapping!

Of course, real interchange demanded other standards in card stock, card size, hole size, placement, and orientation. I.e., there had to be a right side up!

Interchange via Reels of Magnetic Tape

Here the assignment of which bit to which track was the main question. Here again, IBM proposed, and ECMA was indisposed. The very real stalemate was broken at the ISO/TC97 meeting in Paris in March of 1957, via the famed "ECMA Compromise" crafted by Clamons, expounded (in the very room where Kissinger dickered with the Viet Cong) by me in my capacity of ECMA member due to working for Bull General Electric at the time.

Interchange via Communication Media

Here a most critical question (among others) was the bit order in serial-by-bit transmission. Read bytes backward and you get garbage. X3.3 owned this decision, not the codes committee X3.2. IBM attempted the first say [50], which proposed that the high-order bit be transmitted first, and discussion became heated [52, 54, 56]. AT&T and Teletype thought it should be low-order bit first though the proposals on both sides maintained columnar adjacency). This latter scheme, argued in [26] by Booth of AT&T and myself, was the winner [71, 72], although more than a year later.

ASCII-ALTERNATE SETS AND THE ISO REGISTRY

Any Internet user will have noticed that search engines turn up pages in various languages. And, if you are not already a user for some language that shows, you will be invited to download the mechanisms to permit your computer to display the characters of that language, for which basic ASCII does not suffice. Explore "www.itscj.ipsj.or.jp/ISO-IR", and you will find the nearly 200 character sets auxiliary to ASCII. AFNOR, the French standards institution, maintained this originally as custodian and registrar, then ECMA, and now the Japanese Information Processing Society. It's a lot of work.

This results from my decade of effort to get my registry concept adopted. Registry is a method somewhat short of a single standard, and thus does not require all of the ponderous and time-consuming processes that an individual standard does. Now that is what drives laser printers and screens all over the world, as though everyone had always agreed "Of course! That's the way to do it!"

Many lead participants in developing ASCII (Footnote-8) thought registry via assigned escape sequence to be a vital component of the entire ASCII system.

Recall that the original charge [152] for the standards work that yielded ASCII said " ... with orderly provision for expansion and alternatives".

The concept came from my verbiage in Ref. [9], 1960 Jan, which said:

"4. Expansion of Set -- Future expansion to a set larger than 120 may take place in two ways. One is to assign additional characters to presently unassigned 8-bit codes ... The second method is to define a shift character to "escape" to another character set. Thus, whenever the shift character is encountered, the next character (or group of characters) identifies a new character set, and subsequent codes are interpreted as belonging to that set. Another shift character in that set may be used to shift to a third set, which may again be the first set or a different set ..."

FN-8

X3.2 Chairman Eric Clamons: *Bob's contributions .. one that affected the industry more profoundly than any other: the proposal to include the ESCAPE character in ASCII... To a large extent the ESCAPE code made ASCII what it is. ... The ESCAPE code also opened the way toward "data streaming", an idea that made possible the widely-used softcopy control standard ...*

X3 Chairman John Auwaerter: *The impasse was broken by Mr. Bemer's "escape" code and registration of alternative meanings ...*

ACM President Walter Carlson: *His idea ... was to use an "escape sequence", whereby each natural language had its own registered escape sequence code and associated set ...*

This was the first public use of the term "escape" for such a purpose, and the

use of multiple characters following ESC was foreseen. See for example the HTML escape sequences to one such set, as bracketed between "&" and ";".

In Ref. [10], 1960 Feb:

The emergence of a single standard from a welter of competing precedents depends upon two solutions: 1) selection or development of an adequate and logical standard, 2) phasing out (or peaceful coexistence with) the old varieties. This paper deals with the latter problem and proposes the mechanics for a solution in the area of character codes, represented by bit combinations ... I propose that one of these combinations, the same one for all standards, be reserved as an "escape" character.

Let us make provision for this "escape" combination to interrupt normal decoding of a stream of characters. It will say, in effect, that "the next T-bit combination is to be considered a numeric identifier of a particular standard". From then on until interrupted by an "escape" character in that set, all combinatorial T-bit characters will be interpreted according to that standard. Shifting from one standard to another is therefore dynamic.

This was the first and primary description of the escape character. And that is how it is used over 40 years later, but not without obstacles and delays. (Footnote 9).

In Ref. [37], 1963 Aug, page 35, it was said:

"6. The ESCape code provides for 127 alternate sets in the 7-bit set, 255 in the 8-bit set. Some of these sets may have official standing ... (Footnote-10):

"8. ... The ESCape characters may be used to shift to one or more special sets containing all of the characters of ALGOL ... Other sets may be reserved for special languages for typesetting ..., etc."

FN-9

The full text has been reproduced in <http://www.bobbemer.com/ESCAPE0.HTM> if you want to see it. The number of possible alternates is now greater, with more than one intermediate character in use.

FN-10 *Again, this is to my knowledge the first mention of "official standing", as the current Register gives them. The term is the essence of the origin of the ISO Register.*

Ref. [84], 1967 Apr, said:

"... The standardization process might, in the future, yield some alternate standard codes for special purposes, which are in a sense subordinate to and linked through USASCII."

Ref. [100], 1968 Jun 18, finds ECMA Secretary General Dara Hekimi understanding the entire purpose of registration, in a way that neither the U.S. nor European workers had so far.

"Furthermore it is possible to define two or more specific USASCII characters for a predetermined (!) ESC-sequence having the meaning: 'go to peujabi alphabet'. The characters of this alphabet will in turn (be) represented each by a different 7 bit combination and not by the original USASCII characters. ... We know that this is not what we mean by EXTENSION."

This document was accompanied by my working paper "REGISTRY -- A New Feature for ISO Recommendations". This paper exists in full, in almost the original form, at <http://www.bobbemer.com/REGISTER.HTM>. It was the definitive and winning argument that led to the establishment of the International Register.

Ref. [104], 1968 Sep 12, showed (as example only) that Hekimi's lesson was learned:

ESC * J ESC % k	means:	from now on communicate with Japanese 7-bit Alphanumeric Code in normal state, and 7-bit KATA KANA code in SO state
ESC * F ESC % m	means:	from now on communicate with French 7-bit code (NF Z 62-010/67) in normal state, and 7-bit mathematical table in SO state

In Ref. [122], 1970 April, the groundwork for the Registry was finally laid. At last! After a decade of pressures had passed. And the good ECMA people extended the concept properly to national variations:

- Procedure for recording of escape sequences (Document 97 12 N 409)

"... In the course of the Naples meeting (1969 May 12-14), it has been decided to set up a "recording authority" for the escape sequences of the ISO 7-bit coded character set, and AFNOR had been proposed to take charge of this responsibility. A group of experts met at PARIS in September 1969 to edit a recording procedure. This procedure, once approved as ISO Recommendation, will permit to work out a document under conditions more rapidly acceptable than those required for the approval of an ISO Recommendation."

Ref. [141] contains an elaboration of possible ASCII-alternate sets:

"ISO TC46, Documentation, has a Subcommittee on Automation in Documentation. This body has responsibility for collecting and/or developing the pages of encoded symbols. Examples ... are:

- *Characters to form natural languages (alphabets) ... Cyrillic, Greek, Hebrew, Arabic, Sanskrit, Braille, Kata Kana, Kanji, dactylogy (hand signs), ... other punctuation.*
- *Symbols of various fields ... Aeronautics, Astronomy (Astrology), Biology, Botany, Business, Chemistry, Ecclesiastical, Fraternal, Electricity and Magnetism, Flowcharts, Games, Heraldry, Logic diagrams, Mathematics, Geometry, Physics, Medicine, Meteorology, Money, Music, Philately, Pictorial, Ornaments, Transportation, Typography, Welding ... other scientific.*
- *Controls for changing point size, weight, slope, font, position relative to the base line, horizontal compression, etc."*

Finally, in Ref. [147] of 1979 Jul, the conclusion was:

"Over ten years ago it was recognized that ASCII was the basis for codification of the various symbols used throughout the world."

"The methods are in place for codifying all symbols that people use. They may be language alphabets. signs, drawing symbols, or controls for equipments. Robots, for example. ... How about a control set or two for sewing machines?"

The question about sewing machines was very serious! And the UNICODE supporters don't seem to have considered this even larger aspect. What, for example, is the UNICODE base-16 value for the United States flag? Will they too have to use the Registry?

QUESTIONS THAT REMAIN

Four decades give one time to mull the implications of IBM's actions during the development of ASCII. Now there are some questions to ask of the insiders still living.

One such is Fred Brooks. Why did he find it necessary, when EBCDIC was chosen, to tell me that they had to give up ASCII because the printers and card punches were not yet ready in ASCII form when it became mandatory to announce the 360 as soon as possible? Think of that, as some have since. There seems no strong reason why these fairly passive devices could not be finally adapted between announcement and first delivery.

I have lived with, and published, that explanation for many years. Now the attitude is "No more! What is the truth?"

There could have been three options in case of major difficulties:

1. Say "Surprise, surprise! You can operate your 360 in either ASCII or a superset of our previous code" ... "and we supply an operating system for the latter", or
2. "You can buy an EBCDIC 360, or you can buy an ASCII 360. Take your pick.", or
3. "We made a mistake in our original support of ASCII. The 360 is going to have a new code never before used, even though you may recognize some of the old characters used in your files."

The argument for 1) is that the 360 was designed with what was/is known as a "P-bit", which, set one way, made it an EBCDIC machine, and, set the other way, made it an ASCII machine.

The argument against *both* 1) and 2) is that, in what is now known as the greatest ever computer snafu, Fred Brooks' programmers embedded EBCDIC characteristics in the most (until then) expensive software in history. When the P-bit was set to ASCII mode, none of the software would work! (Footnote-11). Much to everyone's surprise. That left only 3), and the remaining questions are:

- When was IBM management aware of this awful predicament,
- When did IBM actions about ASCII change to mirror their dilemma?
- Who (high-enough up) orchestrated IBM's turnaround?

I cannot give definite answers. But analysis may be facilitated by the special marker † placed in the text wherever an adverse IBM-caused action is suspected.

FN-11 As additional evidence that this group of programmers was out of control, they also, at that time, saddled much of the world with the embedded characteristics of the 2-digit year, a problem that surfaced viciously some 30 years later (even though the matter was being discussed in X3 at the time).

THE SOBRIQUET

A Google search of the Web for "Father of ASCII" currently yields about 90 hits, all referring to this author. An editor of Computerworld once suggested that it was self-assigned. And many places that the phrase is used are in error. So the matter should be dealt with here, integral to this history.

First we must recognize that the word "ASCII" is now generic, even though I tried for a long time (unsuccessfully) to have it called the "ISO Code". And we must recognize three large segments or aspects of the ASCII world:

- ASCII Art
- ASCII The Coded Character Set
- ASCII The Base for ALL Coded Character Sets, and the Web

So is "Father of ASCII" correct for all of these? Well, yes and no.

ASCII Art

This one was surprising. There are thousands of websites devoted to making pictures of a sort with the graphic symbols of ASCII. Of course with a system of dot combinations, formerly called "rotogravure", they'd be even happier. That was sort of done once, in a registered ASCII variant called "Teletext".

But the parenthood would apply only to the set of graphic symbols. In [162] it is shown that I contributed, via accepted proposals, the characters `{ } [ \ ] ESC` to ASCII, and that none of these had ever existed in the internal character set of any computer before STRETCH (with the possible exception of square brackets in the character set of the LGP-30).

US (Unit Separator), RS (Record Separator), GS (Group Separator), and FS (File Separator) are 4 other characters that I put in very early, but without those names. And they have no graphic shape, anyway. The backslash seems to be the character that would be most missed.

ASCII The Coded Character Set

The text so far shows that I had much influence in putting the standards efforts, in the U.S. and worldwide, into action.

But I exerted little fatherly influence, leaving the selections and code placement to the international bodies who did that as their primary reason for existence. J.A.N. Lee said, in his bio for me in [155] that:

" ... He was not the inventor of ASCII ...

True. ASCII was not "inventable". There was no way to achieve a standard code of the present universality without leaving it to a vast group of manufacturers and workers. Lee explained as much. But he added that:

Bemer's forceful articulation and demonstration of the simplicity of the "escape sequence" solution achieved acceptance of a US standard that rendered as nonstandard all existing computer designs, software systems, and telecommunications hardware, including the whole repertoire of IBM equipment that used EBCDIC ..."

I attempted to explain the "father" usage in a letter to BYTE Magazine [154] in response to a man who claimed [153] that ASCII was obsolete:

But it is not correct to say that I created ASCII. To say this insults many people who dedicated years of their lives working out compromises between dozens of existing codes for the resultant single code. I have never demurred at being called the "father of ASCII", as it is the "mother" who creates.

I did get X3 to agree to move the alphabets to where they are now, reserving three positions following them for international usage in ASCII-alternate sets. And I did maneuver the development work to be done on an international basis, ensuring the cooperation and support of all countries.

ASCII -- The Base for ALL Character Sets, and the Web

Now the real fathering, of the mechanisms that enable the Worldwide Web.

From the beginning of my interest in standard encoding methods, I saw the problem not as creating a single standard code, but as having a basic code and system from which the multitude of graphic symbols in the world could be encoded in groupings reached by temporary departure from the base system. I envisioned alternate coding tables, which could be invoked dynamically as identified by

"an identifier self-identifiable as an identifier"

Thus the genesis of the "escape" character. Like the "Now hear this" on a Navy ship, followed by a message to be obeyed, "escape" fits the "orderly provision for expansion and alternatives" clause of the original program-of-work statement.

I did not create the sobriquet "Father of ASCII". It came to me in the late 1960s as the parcel address for such a person at General Electric in Phoenix. Someone with knowledge forwarded it to me, and inside was a letter starting "Dear Bob". I accept it for being a major force in the creation and adoption of ASCII, as said in a Marconi Prize nomination in [174].

Remarks on the IBM PC of the Early 1980s

How did IBM, stuck in the EBCDIC morass, ever get to design and produce its first PC, an ASCII-based machine? One could give several answers:

- Existing PCs, regardless of sales volume, were ASCII-based.
- The rise of communications networks made it probable that the PC would be used more as a network terminal than as a standalone computer, and the networks were ASCII. And so it turned out!
- Some ingenious IBMers discovered a way to do arithmetic directly upon the ASCII codes for the digits. They even patented it. The only problem was that the method could not be adapted to EBCDIC digits with the high 4 bits as "1111", whereas in ASCII they were "0011". This meant "goodbye forever" to the packed-decimal arithmetic developed for the 360, which chews up so many computational cycles.
- Although IBM had by this time, thanks to the foresight of Eric Clamons in forcing a 1-1 correspondence via the punch card code standard for ASCII, a chip that would convert both ways in a flash, why bother, when the collating sequences would still sandbag the user?

WILL ASCII LAST?

Very possibly. The NIST (National Institute of Standards and Technology), an arm of the U.S. Dept. of Commerce, said recently: [158]

"Most modern developments in the computer field, such as the Internet, would not have been possible without this underlying [ASCII] code."

A Computerworld article [156] had this to say:

"If it weren't for a particular development in 1963, we wouldn't have e-mail and there would be no World Wide Web. Cursor movement, laser printers and video games; all of these owe a big debt of gratitude to this technological breakthrough. What is it? Something most of us take for granted today: ASCII. Yep, plain old ASCII, that simplest of text formats."

With respect to UNICODE:

- It may be that not all users will wish to pay the price of doubled memory, no matter if it becomes molecular. And a second "plane" of 65K new characters is under development.
- 2 power 16 characters may seem like enough today, but its symbols are mainly those of alphabetic characters or other language pictographs. There is no room in 16 bits for architectural units, symbolic logic symbols, sewing machine or factory assembly controls, or whatever the next computer usages will be when our minds are augmented further.
- Even now, UNICODE has been forced to accommodate other sets via the time-honored escape sequence identifier.

As to the possibility of ASCII dying out of its own accord, see the last word in the motto of the State of Michigan -- "si queram ... peninsulam, circumspice". Which is translated as "look around you".

A Story of ASCII

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ENDNOTES

EN-1 It would have been nice to make a HTML redo of Table 3. The HTML proponents would have you think this was possible. But not all fonts show all of the special HTML graphics on the screen, and if you pick a font that does -- there is no guarantee that your laser printer will produce it! And my very modern HP 1200 will often not match the line spacing showing on the screen.

EN-2 And if HTML could not be used for Table 3, think of the impossibility for Tables 1 and 2, where many characters are not even given their own HTML sequences. I had to draw those myself with an old-fashioned Leroy ink lettering set.

EN-3 Historical source information on ASCII development is in widely scattered locations. Some at the National Museum of American History (including mine), some at the Charles Babbage Institute, some at the University of Texas (more mine), and other pieces remaining in private hands. It would be impossible to gather all in one place, but at least a roadmap should be made public. Eric Fischer probably has most of this done now, and I hope he gets it published soon.

One place that Eric did not know about is the home of Chuck Card, the last chairman of the X3L2 committee that I had contact with, and a very able one. He has many original microfiche of some earlier, and a lot of the later, proceedings and minutes. And he pledges cooperation with any other researchers. Find him at:

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1454 N Robin Lane
Mesa, AZ 85213
cardcd@earthlink.net
480-854-0624 -- FAX -- 602-964-8873*

EN-4 BEMA became CBEMA and now INCITS (202-737-8888). I can vouch that they made fiche of all early records, because IBM's legal people had them all copied to paper in 1988, so I could make a search for a patent suit brought against them.

But the INCITS fiche seem to have disappeared. I have called several times, and nobody wants to talk to me about them. Very mysterious.

EN-4 Perhaps my special trip to IBM's Typewriter Division should have been mentioned. The printing ball was then designed for 4 rows of 22 characters (or 8 x 11). I made a plea to H. S. Beattie, the chief engineer there, to make 4 rows of 24 characters, so that the 96 non-control positions of ASCII could be accommodated. He shrugged me off with "it'll never be anything but a correspondence typewriter". The slightly increased mass could have been tolerated -- there were oversized balls (Presenter Head) furnished.

This decision is not awarded a dagger, for it had nothing to do with the EBCDIC vs. ASCII situation. EBCDIC could also have used the extra characters.